

Original Research Article

<https://doi.org/10.20546/ijcmas.2021.1003.262>

Comparative Morphology, Phenology and Productive Potential of Different Plant Types in Papaya cv. Red Lady Taiwan

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ABSTRACT

A trial was conducted during 2018-19 to study the comparative morphology, phenology and productive potential of different plant types in gynodioecious papaya cv. Red Lady Taiwan in South Gujarat. The experiment was laid out in non-replicated trial and consisted of 200 papaya plants. Results indicated a gradual increase in plant height, stem girth, leaf area and number of leaves from July 2018 to May, 2019. For vegetative parameters, the differences between pistillate plants and hermaphrodite plants were not very sharp. With regard to pistillate plants, the maximum flowers per plant (5.40) were recorded in October, 2018 and the maximum fruits (13) were harvested in May, 2019. Fruit weight was the highest (2.20 kg) in January, 2019 and fruit yield was maximum (18 kg/plant) in April, 2019. Days taken from fruit set to harvesting in pistillate plants varied from 121.0 to 130.0 days and the insertion height of fruit ranged from 81.40 to 90.40 cm. In case of hermaphrodite plants, highest number of flowers (5.10) was noticed in February, 2019. Fruits harvested per plant (11) were maximum in May, 2019 and the fruit yield (22.10 kg/plant) was highest in April, 2019. Hermaphrodite barren flowers per plant ranged from 1.60 to 2.80 with maximum value (2.80) in October, 2018. The number of misshapen fruits per plant was found maximum (5.0) in May, 2019. Days taken from fruit set to harvesting in hermaphrodite plants varied from 146.0 to 155.0 days and the insertion height of fruit ranged from 86.70 to 98.60 cm.

Keywords

Papaya, Pistillate plants, Hermaphrodite plants, Phenological studies, Fruit yield

Article Info

Accepted:

18 February 2021

Available Online:

10 March 2021

Introduction

Papaya (*Carica papaya* L.) is one of the most important fruit crops of the tropical and subtropical regions of the world popularly known as 'Breakfast fruit', 'Pawpaw' and 'Backyard fruit'. It is native to Tropical

America and was introduced to India in 16th century. India holds first position in the harvested area, production and productivity of papaya in the world. India produces about 6.10 million metric tonnes of papaya from an area of 1.36 lakh hectare with the productivity of 44.9 MT/ha. In Gujarat, the area under

papaya is 0.02 million hectare with the production of 1.24 million metric tonnes and productivity of 61.54 MT/ha. Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu are the leading producers of papaya in the country (Anon., 2017). Papaya is a popular crop among farmers due to regular demand of fruits in the market and high productivity. It is a highly remunerative crop providing more income on per hectare basis, next only to banana.

In South Gujarat, Red Lady Taiwan is preferred by growers due to its orange red colored pulp and excellent quality with high yielding potential. It has emerged as a replacement of Madhu Bindu variety in Gujarat owing to its high productivity, flesh colour and gynodioecious nature. Phenological studies are important for understanding the influence of weather on vegetative growth, flowering and fruiting of a crop. Further, Red Lady Taiwan is a gynodioecious variety and consequently female as well as hermaphroditic plants are found within the population. It was felt worthwhile to study the differences between these two populations, as well. There are hardly any phenological studies in papaya under Gujarat conditions or comparative studies between pistillate and hermaphroditic plants of cv. Red Lady Taiwan. With the above background, phenological investigations were planned in papaya cv. Red Lady Taiwan when grown in South Gujarat.

Materials and Methods

An experiment to study the phenological characters in papaya cv. Red Lady Taiwan was conducted during 2018-19 at Instructional Farm, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari, Gujarat. Papaya seedlings, when seven weeks old were

transplanted in May, 2018 at a distance of 2 m x 2 m. They were treated with the Recommended Dose of Fertilizer 200:200:250 g NPK per plant after 2, 4, 6 and 8 months of transplanting. This was a non-replicated trial comprising of 200 plants. Uniform cultural practices as recommended by NAU were adopted for the cultivation of papaya crop. Vegetative parameters like plant height (cm), stem girth (cm), leaf area (cm²), number of leaves per plant were recorded at monthly intervals from the 2nd month up to the 12th month after planting. Floral characters such as days taken for first flower initiation, number of flowers (pistillate, hermaphrodite elongate and hermaphrodite barren flowers) and insertion height of first fruit (cm) were observed from September, 2018 onwards. Whereas, fruit yield and associated traits *viz.*, days taken from fruit set to harvesting, number of fruits per plant, fruit weight (kg), fruit diameter (cm), fruit length (cm) and fruit yield (kg) were studied from February to May, 2019. In South Gujarat, papaya is commercially grown as an annual crop and therefore harvesting was discontinued after May, 2019 and the crop was uprooted from the field.

Results and Discussion

The vegetative, flowering and fruiting characters of any crop are influenced by the agro-climatic conditions of that particular area. Results of this phenological investigation are discussed under the following subheads.

Vegetative traits

There was a perceptible variation between pistillate and hermaphrodite plants of papaya cv. Red Lady Taiwan for various vegetative characters throughout the study (Table 1). Plant height and stem girth showed a gradual increase from July, 2018 to May, 2019

regardless of plant type in cultivar Red Lady Taiwan. Further, the maximum increase in plant height was observed during August, 2018 (40.48 and 39.06 %) while, the minimum increase was noticed in January, 2019 (6.58 and 6.43 %) in pistillate and hermaphrodite plants of papaya, respectively. Stem girth exhibited a trend similar to that of plant height with the maximum increase in stem girth during August, 2018 (49.23 and 43.94 %) and the minimal increase in January (6.04 and 6.16 %). As far as leaf area was concerned, it was found minimum in July, 2018 (159.50 cm² and 160.41 cm²) and maximum in May, 2019 (539.70 cm² and 523.02 cm²). Further, number of leaves was least during September, 2018 (11.55 and 11.10) and highest during March, 2019 (33.30 and 31.30) in pistillate and hermaphrodite populations of cv. Red Lady Taiwan.

Vegetative parameters like plant height and stem girth increased at a quicker pace during the initial stages of the growth while, it was a bit slower at the later stage of papaya life cycle. Such differential response may probably be due to ageing of papaya plants. Environmental factors may also be responsible as higher temperature at the initial stages of growth may have increased the photosynthesis, respiration rate and metabolic activity of the plants. This is in consonance with the finding of Allan *et al.*, (1987) wherein, they reported rapid plant growth under high temperature regime in papaya. This also explains the higher leaf area and number of leaves in the summer season (March-April, 2019) as compared to the winter season (December, 2018 - January, 2019) in South Gujarat region.

Floral parameters

The flowering habit in papaya is variable as it is highly cross pollinated crop. A perusal of Table 2 indicated definite variation in days

taken for first flower initiation (102 to 111 days) and insertion height of first fruit (86.70 to 98.60 cm) in hermaphrodite plants of papaya cv. Red Lady Taiwan. Same was the case with pistillate plants wherein days taken for first flower initiation ranged from 98 to 107 days and insertion height of first fruit ranged 81.40 to 90.40 cm in pistillate plants. Lower insertion height is an indication of earliness and is also preferable for ease in harvesting. It is evident that pistillate plants flowered and fruited earlier than hermaphrodite types in papaya cv. Red Lady Taiwan.

Papaya plants of cv. Red Lady Taiwan flowered from September, 2018 onwards. Pistillate and hermaphrodite barren flowers were observed starting from September, 2018. However, flowering was late in hermaphrodite plants bearing elongate flowers (October, 2018 onwards). Maximum pistillate flowers (5.40) were observed during October, 2018 and the least number of pistillate flowers (3.90) in January, 2019. Further, number of hermaphrodite elongate flowers was noted maximum (5.10) during February, 2020 and minimum (3.80) in May, 2020. High temperature accompanied by dry conditions adversely affect flowering in papaya (Saran *et al.*, 2015). Hermaphrodite barren flowers were lowest (1.60) in March 2020 and the maximum (2.80) in October, 2019. The hermaphroditic plant appears to be a reservoir of transformation gene(s) with adverse conditions resulting in staminate flowers and favourable conditions resulting in true hermaphrodite flowers or even females (Odu *et al.*, 2006). Flower production was subdued in the winter season and this may be due to slow flower bud development under cooler conditions (Allan, 1958 and Allan *et al.*, 1987). Minimum temperatures below 10° C significantly affect pollen viability, possibly as a consequence of degenerated pollen mother cells (Allan, 1963).

Besides, due to different genetic constitution in gynodioecious varieties, there always remain some morphological differences and different sex types like females and hermaphrodite (Bharathi and Dinesh, 2012). Thus, it can also be attributed to differences in inherent nature and exposure response to climatic factors (Kore *et al.*, 2017). The present results are in line with reports by Anh *et al.*, (2011), Bharathi and Dinesh (2012), Jamaluddin *et al.*, (2015) and Ara *et al.*, (2016) in papaya (Table 3).

Fruit yield and associated traits

It is evident from the data presented in Table 4 and 5 that there was variation in days taken from fruit set to harvesting in hermaphrodite plants (146 to 155 days) and in pistillate plants (121 to 130 days) of papaya cv. Red Lady Taiwan. Fruit setting is highly dependent on pollen viability but the pollen production and viability are adversely affected by cold winter conditions, which leads to necrosis of pollen mother cells, while high and low temperatures (>32 °C and <10 °C) have a temporary adverse effect on pollen viability. So fruit set, development and maturity is affected by prevailing temperatures and competition with earlier set fruit (Allan, 2002).

However, under the prevailing agro-climate of South Gujarat (May planted crop), fruit set is observed in September-October and fruits are ready for harvesting in February-March. Nevertheless, hermaphrodite plants may fail to set fruits for short period of time during September and this could be due to moisture stress or unfavourable weather conditions. High temperature accompanied by dry conditions adversely affects fruit set in papaya (Saran *et al.*, 2015).

The maximum number of harvested fruits per pistillate plant (13) was recorded in May,

2019 and the least value (5) was registered during February, 2019. Number of fruits borne on hermaphrodite plants having elongate flowers and mis-shapen fruits per hermaphrodite plants were found maximum (11 and 5) during May, 2019, respectively. Whereas, it was found least in March, 2019 (4 and 2). If a papaya plant is inadequately pollinated, it will bear a light crop of fruits lacking uniformity in size and shape (Prakash *et al.*, 2015).

The maximum fruit weight (2.11 kg) in hermaphrodite plants was noted during March, 2019 whereas, the lowest fruit weight (1.30 kg) in hermaphrodite plants was observed during May, 2019. Fruit weight of pistillate plants (2.20 kg) was found maximum during February, 2019, whereas the least value (1.30 kg) was observed in May, 2019. Fruit development is often quicker under high temperature regime and even the smaller fruits may have matured earlier. Warmer, intermediate temperatures with wider diurnal fluctuations in temperature are optimal conditions for growth and fruit quality (Allan *et al.*, 1987). In South Gujarat, fruits are seldom harvested in the peak summer season owing to small fruit size, inferior fruit quality and competition with mango in the market. Growers schedule their planting in a manner that harvesting is completed by April end or beginning of May.

Fruit diameter of pistillate fruits ranged from 14.20 cm in February, 2019 to 10.30 cm in May, 2019. The corresponding values for hermaphrodite fruits were 11.30 cm in March, 2019 to 9.30 cm in May, 2019. Fruit length of pistillate fruits was found maximum (20.20 cm) during February, 2019 while it was least (16.10 cm) during May, 2019. In hermaphrodite fruits, the maximum fruit length (27.40 cm) was noted during March, 2019. However, the lowest fruit length (22.80 cm) was observed in May, 2019.

Table.1 Vegetative characters of papaya cv. Red Lady Taiwan

Observation periods	Plant height (cm)		Stem girth		Leaf area		Number of leaves (Flowering to harvesting)	
	Pistillate	Hermaphrodite	Pistillate	Hermaphrodite	Pistillate	Hermaphrodite	Pistillate	Hermaphrodite
July (2nd MAP)	45.20 (-)	44.80 (-)	7.17 (-)	7.35 (-)	159.50	160.41	-	-
August (3rd MAP)	63.50 (40.48)	62.30 (39.06)	10.70 (49.23)	10.58 (43.94)	187.90	185.70	9.61	9.97
September (4th MAP)	75.05 (18.18)	75.30 (20.86)	14.78 (38.13)	14.78 (39.69)	332.01	329.71	11.55	11.10
October (5th MAP)	86.08 (14.69)	86.08 (14.31)	17.62 (19.21)	17.70 (19.75)	375.37	381.80	15.15	14.25
November (6th MAP)	95.30 (10.71)	95.50 (10.94)	19.86 (12.71)	19.70 (11.29)	411.00	414.41	18.05	17.65
December (7th MAP)	103.20 (8.28)	102.60 (7.43)	21.50 (8.25)	21.10 (7.10)	435.79	442.04	21.60	21.70
January (8th MAP)	110.00 (6.58)	109.20 (6.43)	22.80 (6.04)	22.40 (6.16)	455.32	465.24	25.89	25.30
February (9th MAP)	122.30 (11.18)	121.50 (11.26)	25.10 (10.08)	24.90 (11.61)	474.70	480.07	29.75	28.85
March (10th MAP)	138.50 (13.24)	138.60 (14.07)	28.10 (11.95)	28.10 (12.85)	494.30	492.80	33.30	31.30
April (11th MAP)	155.60 (12.34)	155.20 (11.97)	32.10 (14.23)	32.57 (15.90)	520.92	512.78	30.65	30.65
May (12th MAP)	172.30 (10.73)	171.16 (10.28)	35.20 (9.65)	35.60 (9.30)	539.70	523.02	27.25	27.95

(Values in parenthesis indicate percent increase)

Table.2 Days taken for first flower initiation and insertion height of first fruit in Papaya cv. Red Lady Taiwan

Floral parameters	Range	Average
Days taken for first flower initiation in hermaphrodite plants	102.00 –111.00	107.10
Days taken for first flower initiation in pistillate plants	98.00–107.00	103.40
Insertion height of first fruit in hermaphrodite plants (cm)	86.70– 98.60	91.30
Insertion height of first fruit in pistillate plants (cm)	81.40– 90.40	84.32

Table.3 Number of flowers in Papaya cv. Red Lady Taiwan

Observation periods	Pistillate flowers per plant	Hermaphrodite elongate flowers per plant	Hermaphrodite barren flowers per plant
July (2 nd MAP)	-	-	-
August (3 rd MAP)	-	-	-
September (4 th MAP)	4.70	-	2.20
October (5 th MAP)	5.40	3.90	2.80
November (6 th MAP)	4.80	4.30	2.10
December (7 th MAP)	4.40	4.80	1.90
January (8 th MAP)	3.90	4.60	2.30
February (9 th MAP)	4.30	5.10	2.00
March (10 th MAP)	4.80	4.90	1.60
April (11 th MAP)	5.20	4.60	1.90
May (12 th MAP)	4.50	3.80	2.40
Total	42.10	36.00	19.20

Table. 4 Fruit yield and associated traits of papaya cv. Red Lady Taiwan

Observation periods	Fruits harvested per plant			Fruit weight (kg)		Fruit diameter (cm)		Fruit length (cm)		Fruit yield (kg)	
	Pist	Herma	Misshapen	Pist	Herma	Pist	Herma	Pist	Herma	Pist	Herma
July (2 nd MAP)	-	-	-	-	-	-	-	-	-	-	-
August (3 rd MAP)	-	-	-	-	-	-	-	-	-	-	-
September (4 th MAP)	-	-	-	-	-	-	-	-	-	-	-
October (5 th MAP)	-	-	-	-	-	-	-	-	-	-	-
November (6 th MAP)	-	-	-	-	-	-	-	-	-	-	-
December (7 th MAP)	-	-	-	-	-	-	-	-	-	-	-
January (8 th MAP)	-	-	-	-	-	-	-	-	-	-	-
February (9 th MAP)	5.00	-	-	2.20	-	14.20	-	20.20	-	16.70	-
March (10 th MAP)	10.00	4.00	2.00	1.83	2.11	13.10	11.30	19.30	27.40	15.20	12.60
April (11 th MAP)	11.00	9.00	4.00	1.45	1.70	12.20	10.10	18.00	26.30	18.00	22.10
May (12 th MAP)	13.00	11.00	5.00	1.30	1.30	10.30	9.30	16.10	22.80	11.00	20.80
Total	39.00	24.00	11.00	1.70	1.51	12.50	10.20	18.50	25.50	60.90	55.50

(Pist: Pistillate; Herma: Hermaphrodite)

Table.5 Fruit yield and associated traits of papaya cv. Red Lady Taiwan

Yield parameters	Range	Average
Days taken from fruit set to harvesting in hermaphrodite plants	146.00 – 155.00	148.80
Days taken from fruit set to harvesting in pistillate plants	121.00 – 130.00	125.30
Fruit weight (kg) of hermaphrodite plants	1.30 – 2.10	01.51
Fruit weight (kg) of pistillate plants	1.30 – 2.20	01.70
Diameter of pistillate fruits (cm)	10.30 – 14.20	12.50
Diameter of hermaphrodite fruits (cm)	9.30 – 11.30	10.20
Length of pistillate fruits (cm)	16.10 – 20.20	18.50
Length of hermaphrodite fruits (cm)	22.80 – 27.40	25.50
Yield parameters	Monthly range	Total
Number of fruit per hermaphrodite plants	4.00 – 11.00	24.00
Number of fruits per pistillate plants	5.00 – 13.00	39.00
Number of mis-shapen hermaphrodite fruits	2.00 – 5.00	11.00
Fruit yield per hermaphrodite plant (kg)	12.60 – 22.10	55.50
Fruit yield per pistillate plant (kg)	11.00 – 18.00	60.90

Papaya fruits were harvested from February to May, 2019 with maximum production in April, 2019. Fruit yield per plant was found maximum (22.10 kg) during April, 2019 in hermaphrodite plants, whereas the least value (12.60 kg) was registered during February, 2019. In pistillate plants, the maximum yield per plant (18.00 kg) was noted in April, 2019, whereas the lowest value (11.00 kg) was noted during May, 2019.

Temperatures below 12-14⁰C strongly retard fruit maturation and adversely affect fruit production (Nakasone and Paull, 1998) but higher temperatures, if accompanied by dry conditions, can also adversely affect fruit set (Elder *et al.*, 2000). This variation in yield might be due to pollination, sexual recombination of cultivar and environmental differences that produce a wide array of modified forms in papaya (Sudha *et al.*, 2013). It may also be explained on account of the variation in yield attributes due to various physiological phenomenon *viz.*,

photosynthetic efficiency, rate of translocation of photosynthates from source to sink and photo-respiration that took place in plant body (Tulasigeri *et al.*, 2017). Moreover, yield performance of variety is deemed as a progressive effect of yield attributes. These results are agreement with findings of Aikpokpodion (2012), Meena *et al.*, (2012), Madarbokus and Ranghoo-Sanmukhiya (2012), Das (2013), Kumar *et al.*, (2015), Kaur and Kaur (2017) and Reshma *et al.*, (2017) in papaya.

This study highlights the differences between pistillate and hermaphrodite populations of papaya cv. Red Lady Taiwan when grown in South Gujarat. Based on the evaluation of vegetative parameters, flowering traits, yield and its associated attributes, the following inferences can be drawn.

Pistillate and hermaphrodite plants of papaya cv. Red Lady Taiwan were morphologically similar.

Pistillate plants of papaya cv. Red Lady Taiwan flowered and fruited earlier than hermaphrodite types.

Fruits borne on pistillate plants were roundish in shape and those borne on hermaphrodite plants were elongated or cylindrical in shape.

Pistillate plants were superior to hermaphrodite plants in terms of number of fruits per plant, fruit weight and fruit yield.

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How to cite this article:

Shivakumara. N. R., T. R. Ahlawat, A. K. Pandey, Dharmishtha Patel, Suchismita Jena and Chaudhary. A. D. 2021. Comparative Morphology, Phenology and Productive Potential of Different Plant Types in Papaya cv. Red Lady Taiwan. *Int.J.Curr.Microbiol.App.Sci.* 10(03): 2050-2059. doi: <https://doi.org/10.20546/ijcmas.2021.1003.262>